Measurement of Low Transverse Momentum Direct Photons Via External Conversions in Au+Au Collisions at sqrt(s) = 200 GeV with the PHENIX Detector at RHIC

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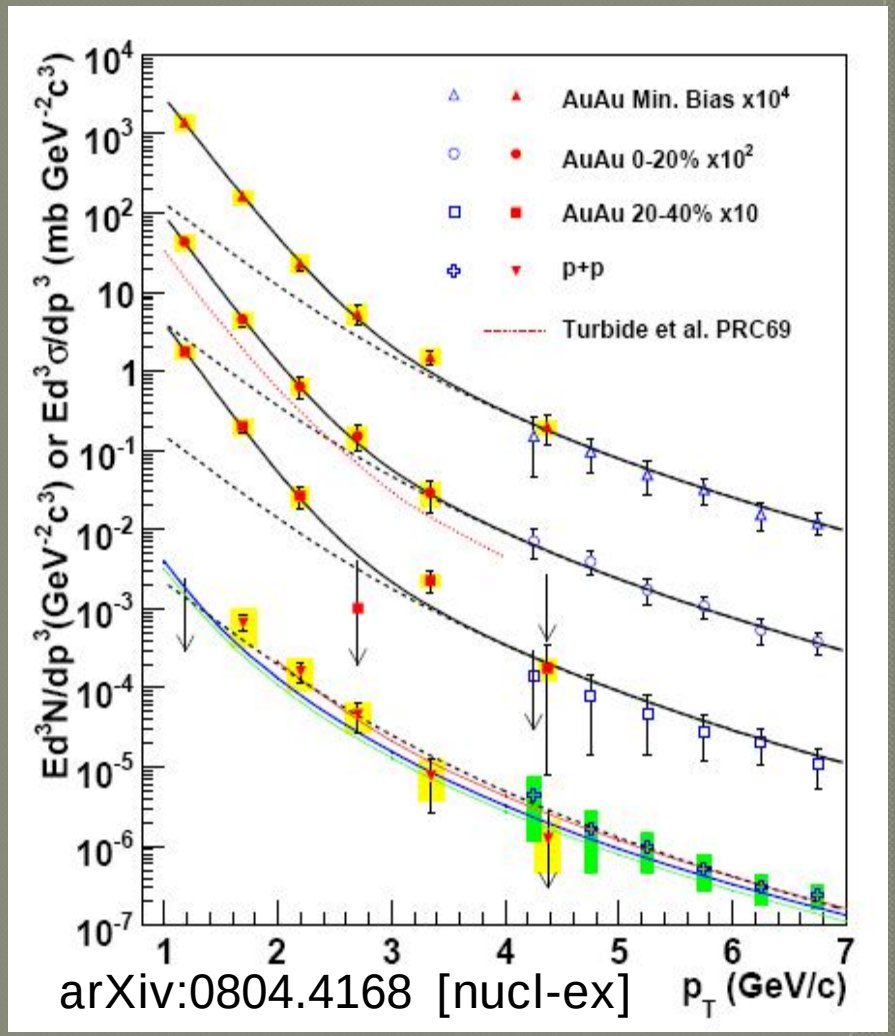
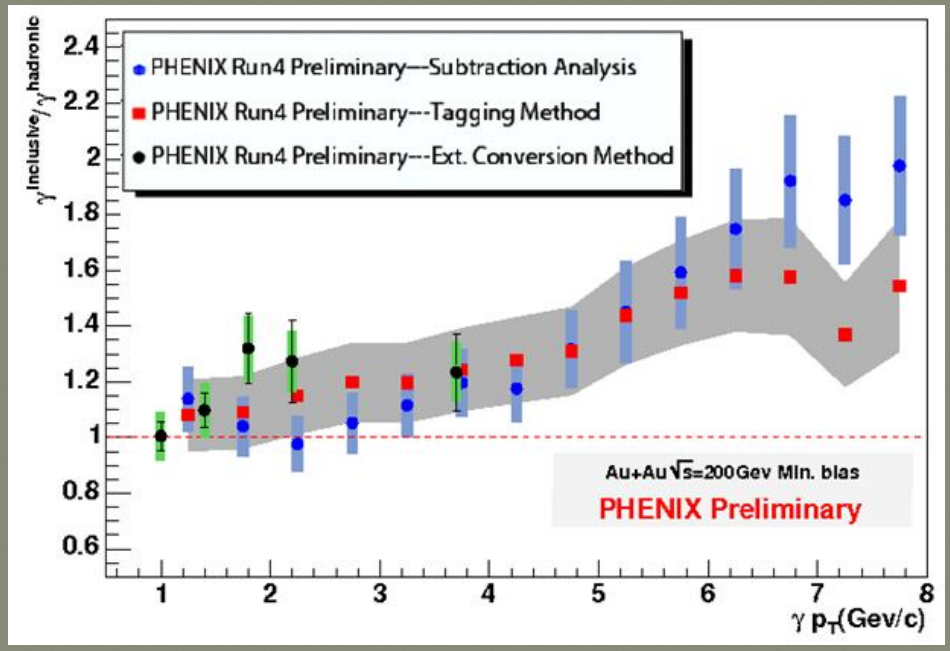
Introduction

- A hot and dense form of partonic matter has been produced at RHIC
- Direct photons are an important probe of this medium
  - Do not interact with the medium
  - Initial temperature
- Just approved for publication in PRL: *Enhanced production of direct photons in Au+Au collisions at sqrt (s)=200 GeV and implications for the initial temperature*
  - Measure direct photon yield through internal conversions



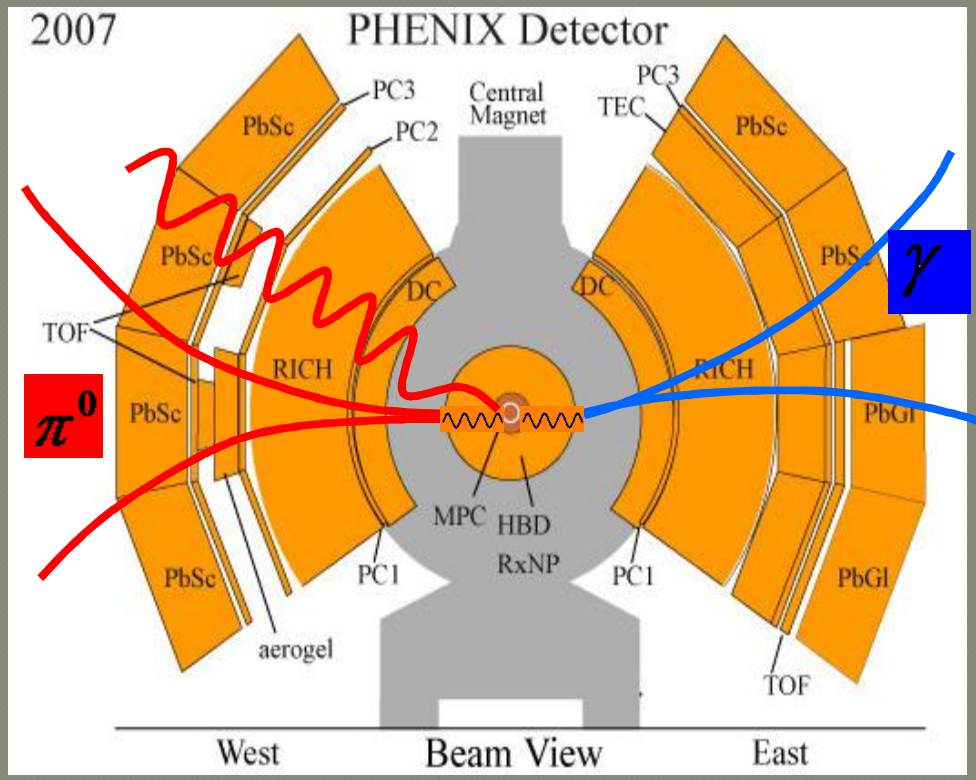
Measuring Direct Photons

- We present a complimentary analysis measuring real photons at low p_T to further support the findings in the paper
  - Measuring photons that *externally convert in detector material*
- Will reduce the statistical errors greatly in Run 7



The PHENIX Detector at RHIC

- Drift and Pad Chambers to measure charged particle momentum
- RICH for electron identification
- Electromagnetic calorimeters for measuring photon energy and ID
- The HBD is used strictly as a converter in this analysis
- BBC forward and backward (not shown) for event vertex determination



Method for Measuring Real Photons through Conversions Through a Double Ratio

$$\frac{\gamma^{incl}(p_T)}{\gamma^{hadr}(p_T)} = \varepsilon_\gamma(p_T)\cdot\left(\frac{N_\gamma^{incl}(p_T)}{N_\gamma^{\pi^0 tag}(p_T)}\right)_{Data} \Big/ \left(\frac{N_\gamma^{hadr}(p_T)}{fN_\gamma^{\pi^0}(p_T)}\right)_{Sim}$$

e+/e- Pair efficiency

DATA

$$N_\gamma^{incl}(p_T) = c\varepsilon_{pair} a_{pair} \gamma^{incl}(p_T)$$

$$N_\gamma^{\pi^0 tag}(p_T) = c\varepsilon_{pair} a_{pair} \varepsilon_\gamma f\gamma^{\pi^0}(p_T)$$

Conversion factor

e+/e- Pair acceptance

Photon efficiency

SIMULATION

$$N_\gamma^{hadr}(p_T) = a_{pair}\gamma^{hadr}(p_T)$$

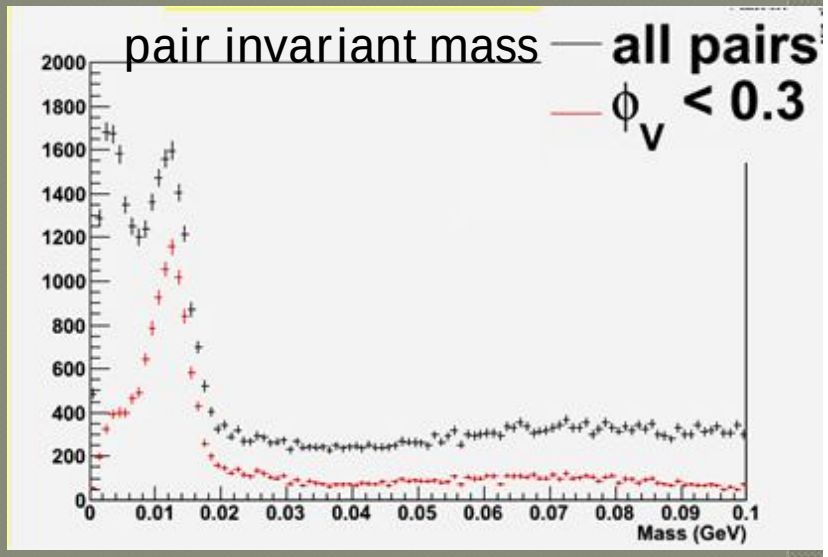
$$N_\gamma^{\pi^0 tag}(p_T) = fN_\gamma^{\pi^0} = a_{pair} f\gamma^{\pi^0}(p_T)$$

Conditional probability of having the photon in acceptance, given that the pair is already in the acceptance

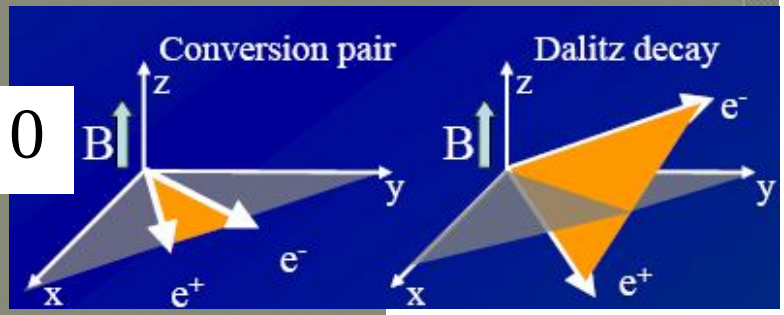
- This method has the advantage of the pair acceptance canceling out in the ratio
- We do not need to know the conversion length of the HBD because of this π^0 tagging method

Conversion Pairs

- The PHENIX reconstruction software assumes all particles come from the event vertex
  - Not true for HBD conversion electrons ($r \approx 60cm$)
  - Acquire an apparent opening angle, and hence an artificial mass
- Conversion pairs will open up perpendicular to the field
  - Dalitz decays will open randomly to the field
  - φ_V angle measures this



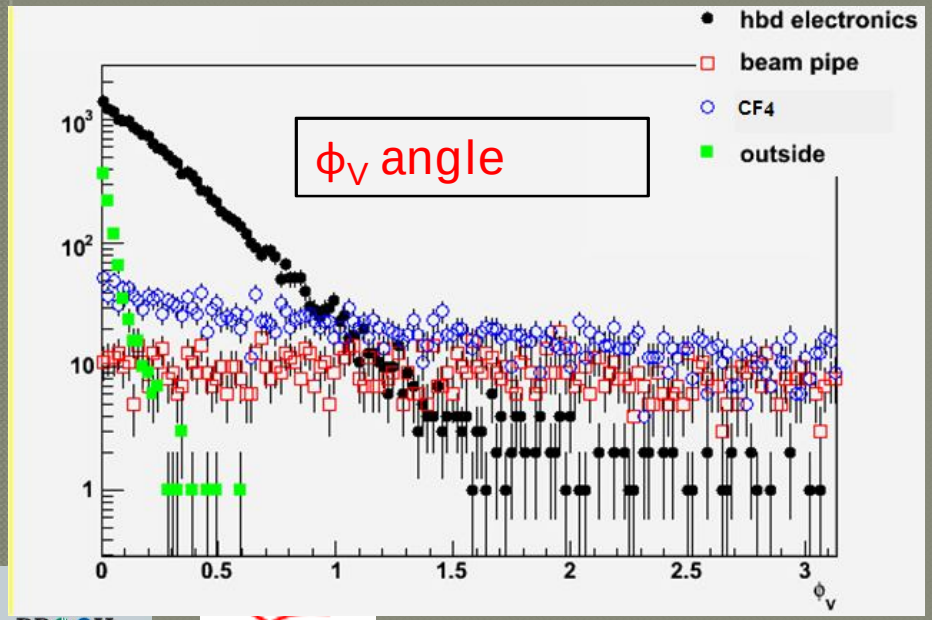
$$\phi_V = 0$$

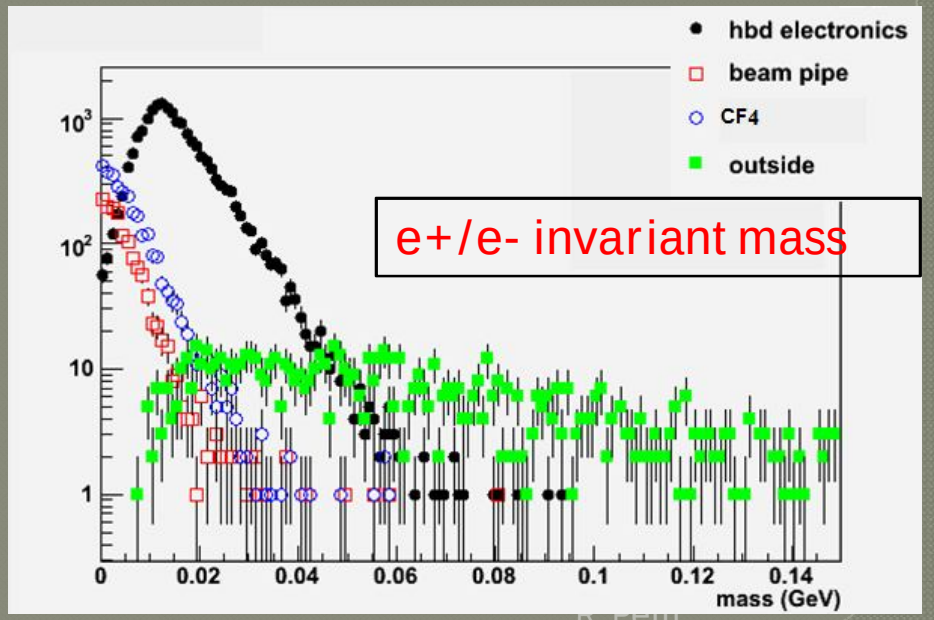


$$\phi_V = \pi / 4$$

Simulation Studies

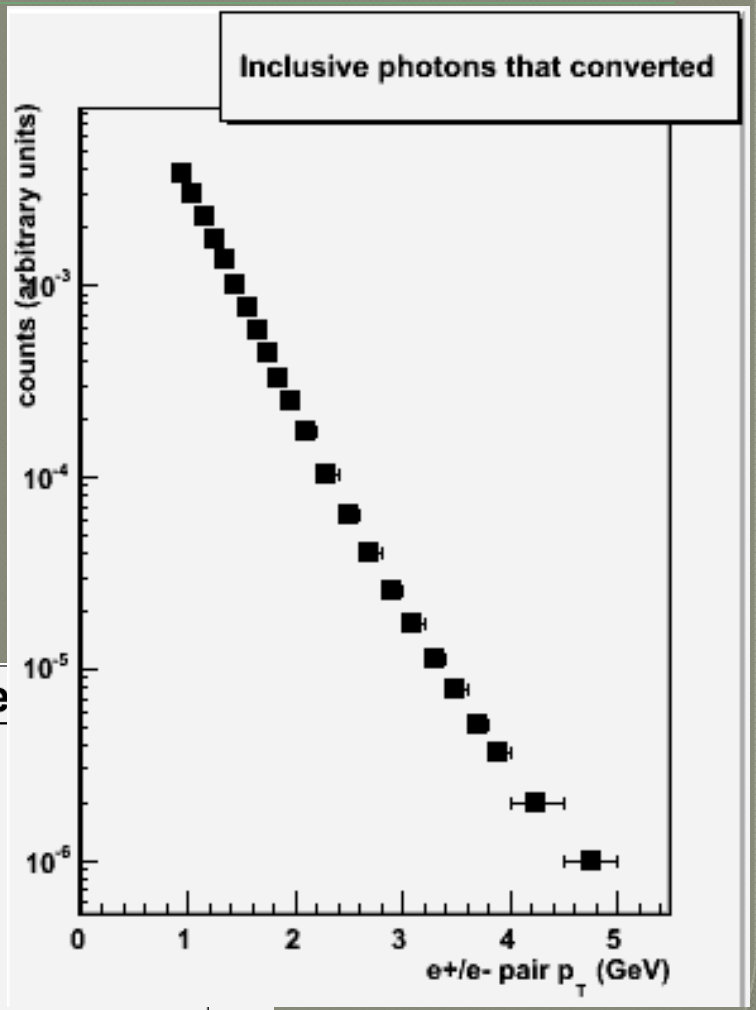
- Simulations show that we can isolate HBD conversions through the apparent mass observed and the ϕ_V angle even in the weaker magnetic field of the +- configuration for Run 7
- Shown are full Monte Carlo simulations of photons, modeling detector response (GEANT) and doing the full PHENIX reconstruction on the simulated data

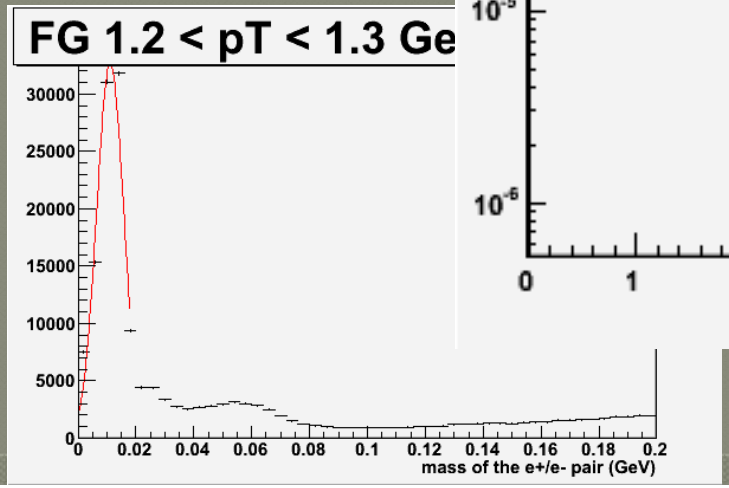




Measuring the Raw Uncorrected Inclusive Photon Sample

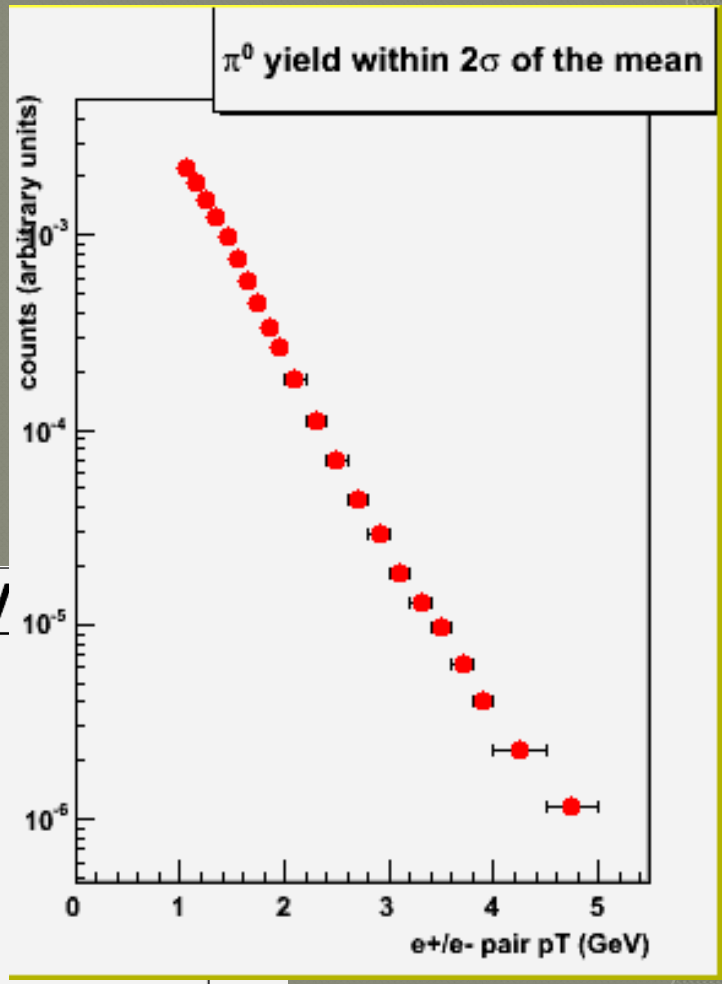
- Electrons and positrons are identified using standard PHENIX eID cuts
  - Number of RICH phototubes fired
  - Shower shape in the emcal
  - Energy/momentum ratio
- Then all electrons and positrons within an event are paired
  - Keep pairs with $\phi_V < 0.3$
  - Pairs with mass < 18MeV are the converted photons

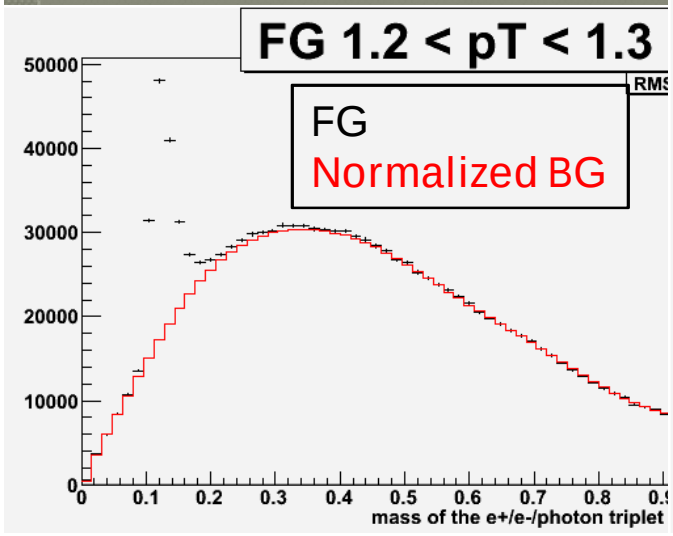


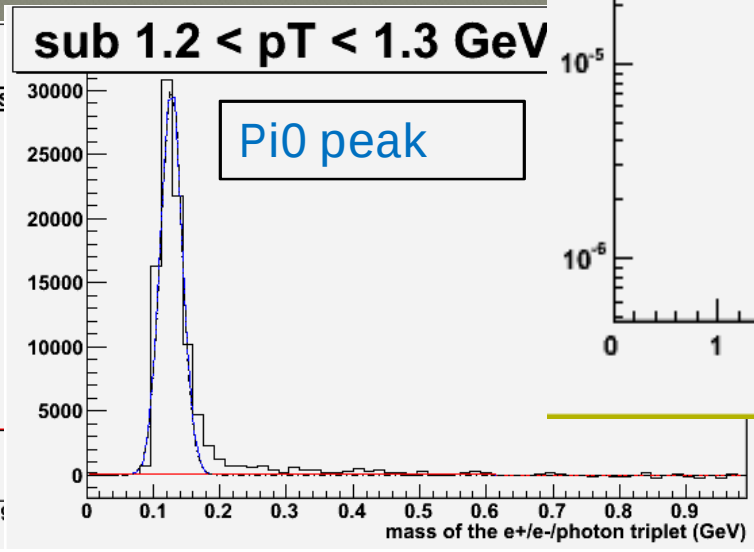


Measuring the Raw Uncorrected π^0 Tagged Sample

- Many of the photons are coming from π^0 decays
- To get a π^0 tagged sample, photons in the emcal are paired with the converted photons found in the inclusive sample
- Combinatorial background is estimated using a mixed event technique
  - Pairs are formed with particles from different (but similar) events to get the uncorrelated combinatorial background







Summary and Outlook

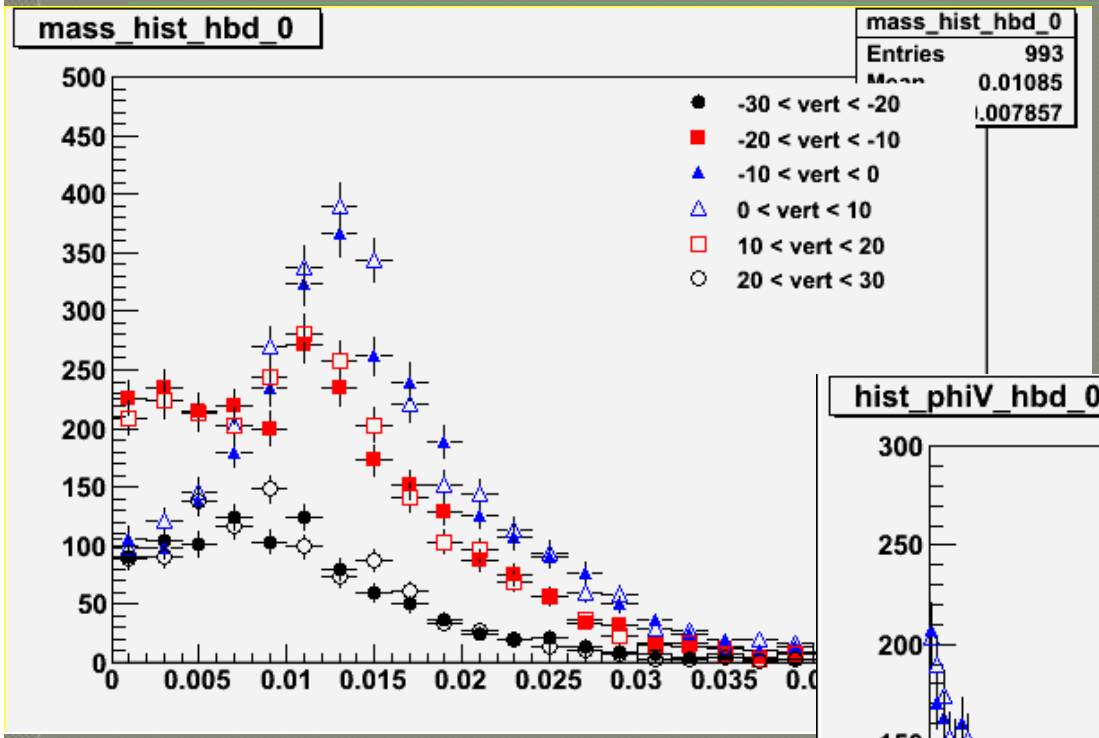
- Progress is being made on measuring low pT real direct photons in Au+Au collisions through an external conversion method
- Raw spectra have been measured for inclusive photons and π^0 tagged sample from 1 – 5 GeV
- Working on getting all the correction factors through Monte Carlo studies
- Working on the denominator in the double ratio estimating other hadronic contributions
- Expect a full result within the year

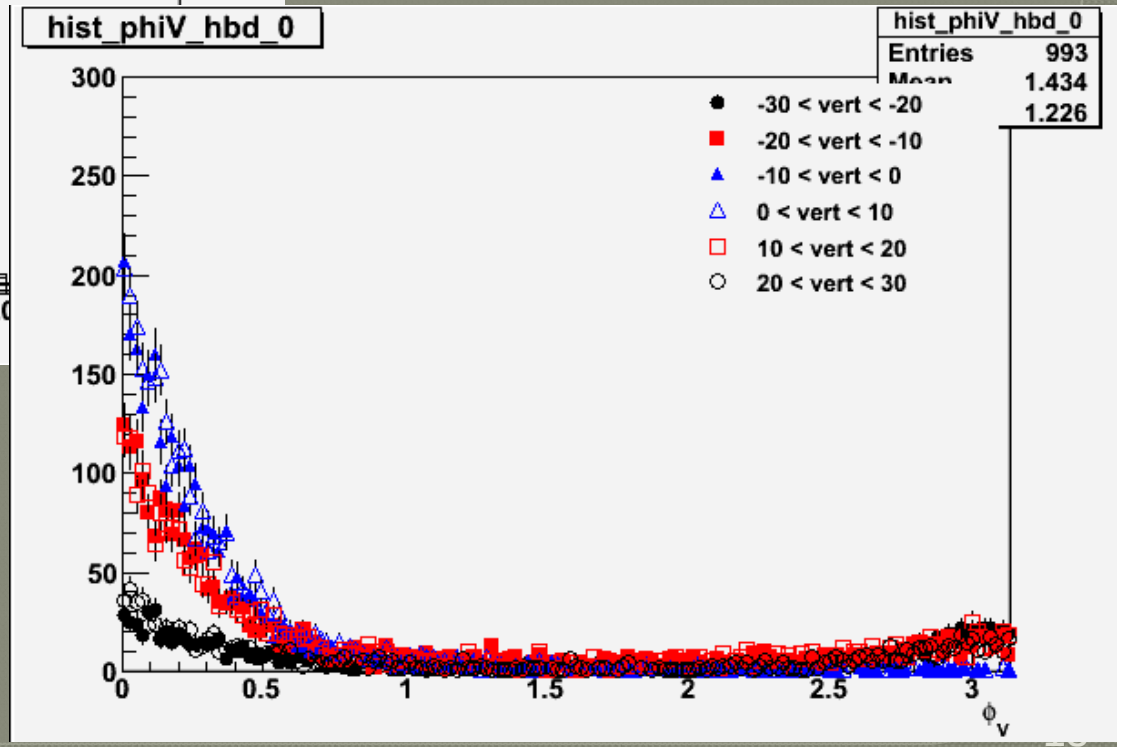
Backups

Relation Between Pair Production and Photon Production

$$\frac{d^2 n_{ee}}{dm_{ee}} = \frac{2\alpha}{3\pi}\frac{1}{m_{ee}}\sqrt{1-\frac{4m_e^2}{m_{ee}^2}}\left(1+\frac{2m_e^2}{m_{ee}^2}\right) S\, dn_\gamma .$$

PhiV Angle and Mass as a Function of Event Vertex





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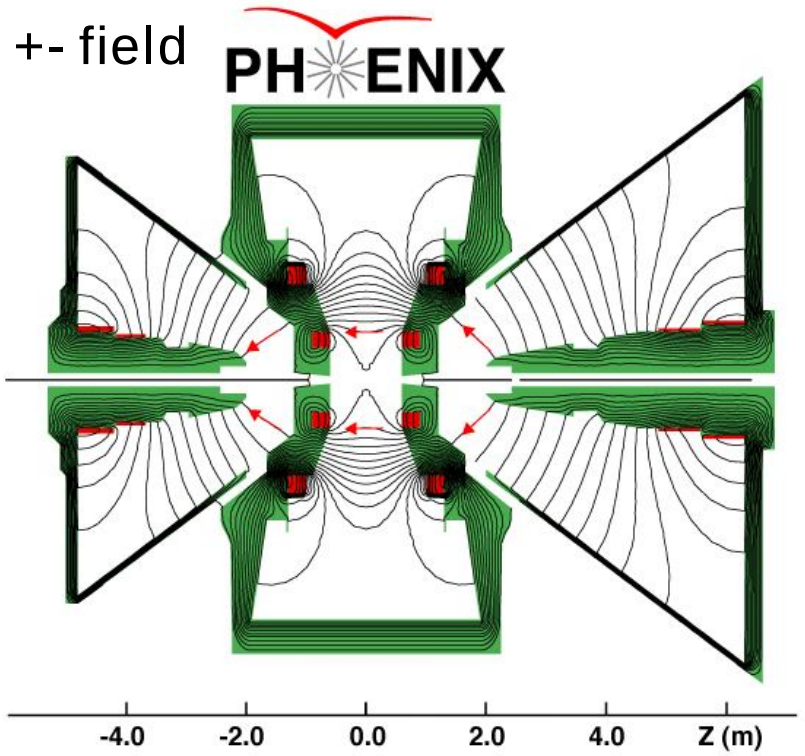
PHENIX

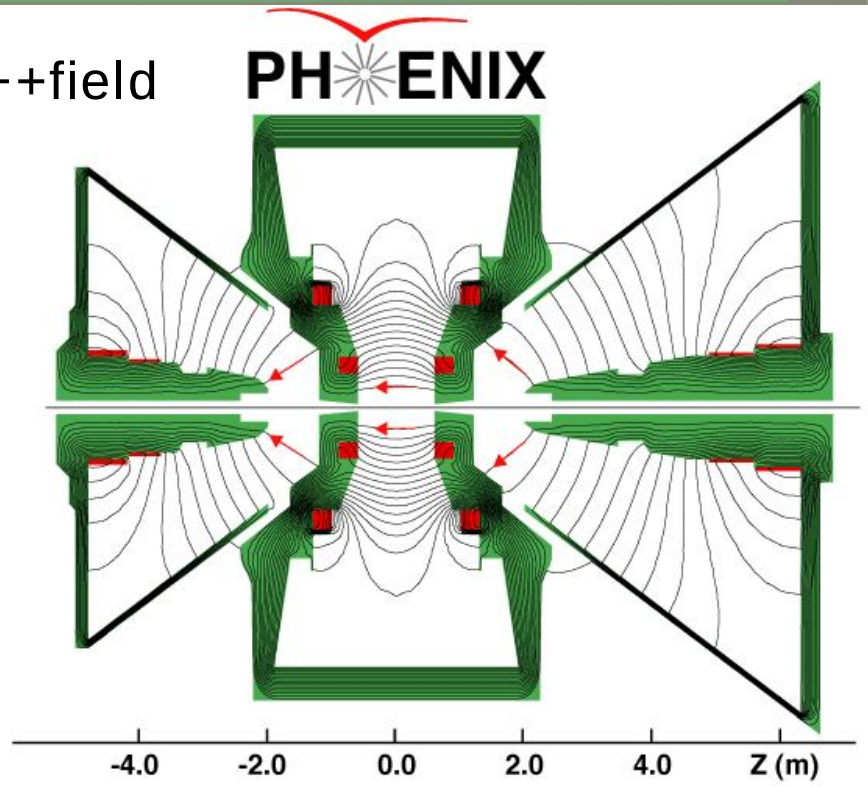
Magnetic Field Configurations

+- field



Magnetic field lines for the two Central Magnet coils in reversed (±) mode

++field



Magnetic field lines for the two Central Magnet coils in combined (++) mode

Advantage of Measuring Photons through conversions to e+/e-

- Photon measurements at low pT are notoriously difficult due to high multiplicity
- Measuring these photons through conversions is a nice way to get around this
- PHENIX has excellent electron identification and so this is a useful channel for study